Do MORBs record the oxidation state of Earth's upper mantle?

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The oxidation state of Earth's upper mantle (OSEUM) is a key thermodynamic parameter as it influences, among other variables, the depth of melting initiation by modifying solidus temperatures, the composition of mantle melts, the speciation of numerous species (e.g., Fe, S, V…), the phase relations, the trace element partitionning, the volcanic degassing… Despite intense focusing on that parameter during last decades, OSEUM remains poorly constrained. OSEUM is either estimated using Mid-Ocean-Ridge Basalts (MORB) $Fe^{3+}/\Sigma Fe$, or the oxidation state of abyssal peridotites[1]. Although MORB display log(fO_2) values ~1 unity above the fO_2 estimate of abyssal peridotites (ΔFMQ=+0.2 and -1.05, respectively [1]), MORB oxidation state is extensively used as a proxy of OSEUM[2-3]. MORB are furthermore the final product of oceanic magma chambers that act as reactive filters[4] through fractionnal crystallization, melt-rock reactions, or contamination at crustal levels. Such processes have the potential to skew the mantle signal during the ascent of MORB to the seafloor. Here we use SIMS measurements to track the contamination component at magma chamber depths, and μXANES measurements to estimate $Fe^{3+}/\Sigma Fe$ of melts crossing the Moho level and of melts from the upper axial melt lens (AML) from which MORB are delivered. We show that AML melts are contaminated through interactions with the hydrothermally altered dikes, and that melts from which cumulates crystallized at Moho depth are less oxidized than MORB melts, delivered from the AML. Mantle derived melts are thus oxidized during their journey to the AML and consequently MORB don't record the OSEUM any more. This oxidation of mantle derived melts may be related to crustal contamination, or to a buffering related to CO_2 degazing during the pressure decrease from Moho to AML.

[1] Foley (2011) *J. Petrol.* **52**, 1363 [2] Kelley and Cottrell (2009) *Science* **325**, 605 [3] Cottrell and Kelley (2013) *Science* **340**, 1314 [4] Bédard (1993) *Geology* **21**, 77